A fast direct coupling between ***LS-DYNA*** and ***RBF*** mesh ***Morph***ing to test different car bonnet designs in simulated Frontal Impact crashes

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Introduction

Figure 1: Honda Accord 2011 (HA11) model

Figure 2: Top view of the External Skin

Figure 3: Bottom view of the Inner Structure

Figure 4: Lateral view of the HA11 bonnet

In the automotive field, design methods can be combined with concept modelling and structural studies in order to obtain a vehicle or a component with optimal static/dynamic performances and preserving safety requirements.

The possibility to automatically modify a computational grid and to adapt it to an existing geometry is a key step to improve testing procedures of different models. Recent advances in optimization techniques and mesh morphing have contributed to the quality improvement of the final product. Using *RBF Morph™* on a bonnet, such as that of 2011 Honda Accord (HA11) (**Figures 1,2,3,4**), allows testing different shape adjustments achieving a very important gain in terms of time [1].

In this context, simulated Crash tests for vehicles have become an indispensable tool for reducing costs and accelerating car development [2]. They are usually performed with the purpose of ensuring safe design standards in crashworthiness and crash compatibility for automobiles or related components. The running of this kind of simulation is often entrusted to explicit solvers.

This work wants to show the possibility to couple *LS-DYNA* explicit solver, one of the most used in automotive design, and RBF mesh morphing in order to test different shapes and models in simulations like Crash tests.

Materials and Methods

The geometric model here presented is made up of 3 solid bodies and 11 Surface bodies. It consists of an External Skin, an Inner Structure, a Reinforcing Frame and several Hinges to join the components together. Concerning the computational grid, the number of Solid elements is 1440 and the number of Surface ones is 37512. The material assigned is a non-linear aluminium alloy with a density of 2800 kg/m³.

Figure 7: Crash test Overview

RBF Morph inside *LS-DYNA* ACT for Ansys Workbench can be used to open the HA11 bonnet: Source Points (SP) are projected towards the Target Points (TP) to modify the mesh with a rigid rotation (**Figure 5**). The same approach can be used for more complex morphing actions, like the one of **Figure 6** that shows how the HA bonnet mesh is morphed into that of the Chevrolet Silverado 2015 (CS15) pick-up. To control mesh-quality degradation, the Skewness of the model is evaluated and a very good quality is achieved even for such an aggressive morphing transformation.

Figure 5: Rigid rotation to open the bonnet: SP in red, TP in blue

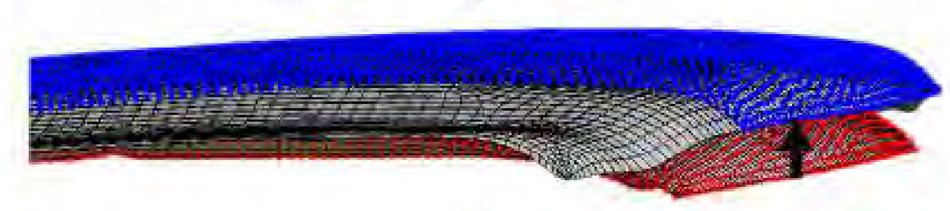

Figure 6: Surface targeting. SP from the starting mesh are moved towards the TP of the CS15 surface

Both the baseline geometry and the morphed car-hood are tested in a Frontal Impact (FI) Crash test using the explicit LS-DYNA solver. The impact wall consists of a quadrangular shell grid of 200x200 elements fixed as Explicit Rigid Body (**Figure 7**). "Body Interactions" tools are enabled and in correspondence with the Hinges, 17 Rigid Remote Connectors are inserted to keep the various components of the bonnet together. The imposed initial velocity towards the wall is 50 km/h. The energy absorption of the two models and the deformations are evaluated.

Results and Discussion

Morphing results: RBF Mesh morphing has proven to be a robust, fast and flexible solution to modify the shape of the bonnet. The first car-hood opening transformation does not change the Skewness of the elements as rigid rotation. The second procedure, that modifies the bonnet of HA11 according to the shape of that of CS15, showed the maximum Skewness increased from 0.51 to 0.74 for Shell elements and from 0.21 to 0.67 for Solid ones.

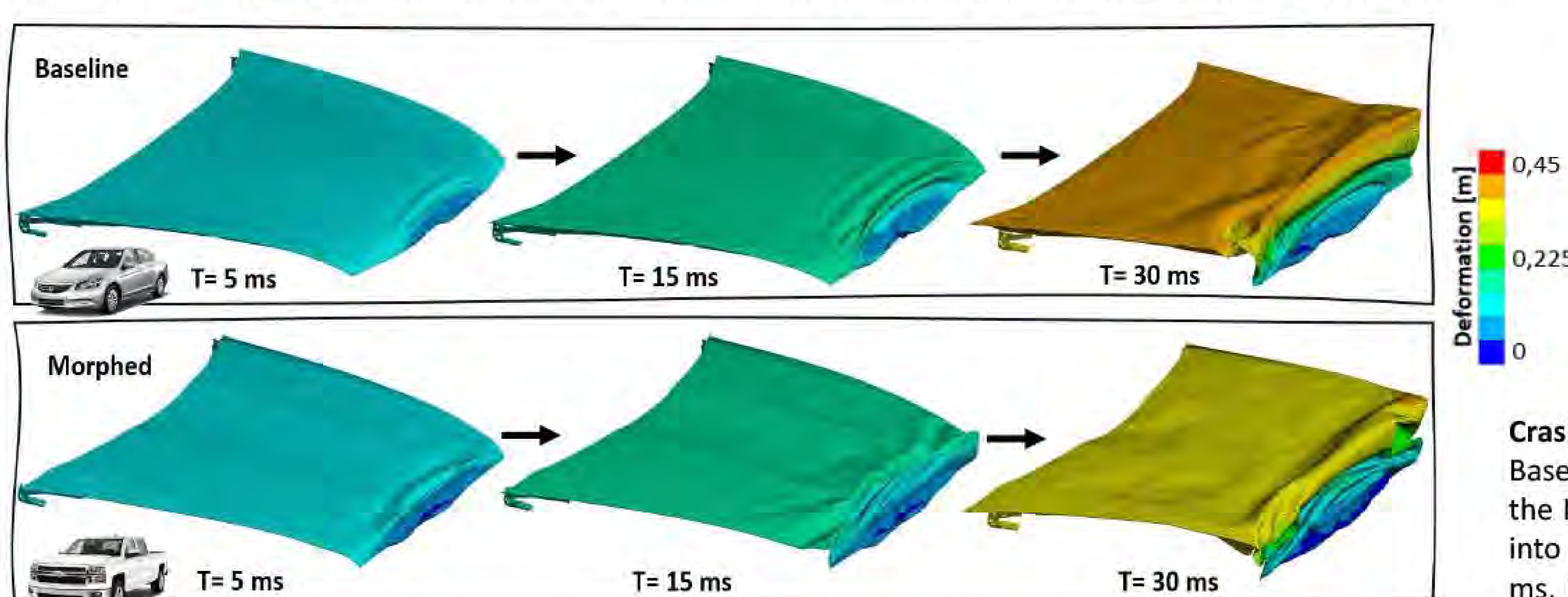

Figure 8: Deformation of the bonnet: Baseline model and Morphed mesh

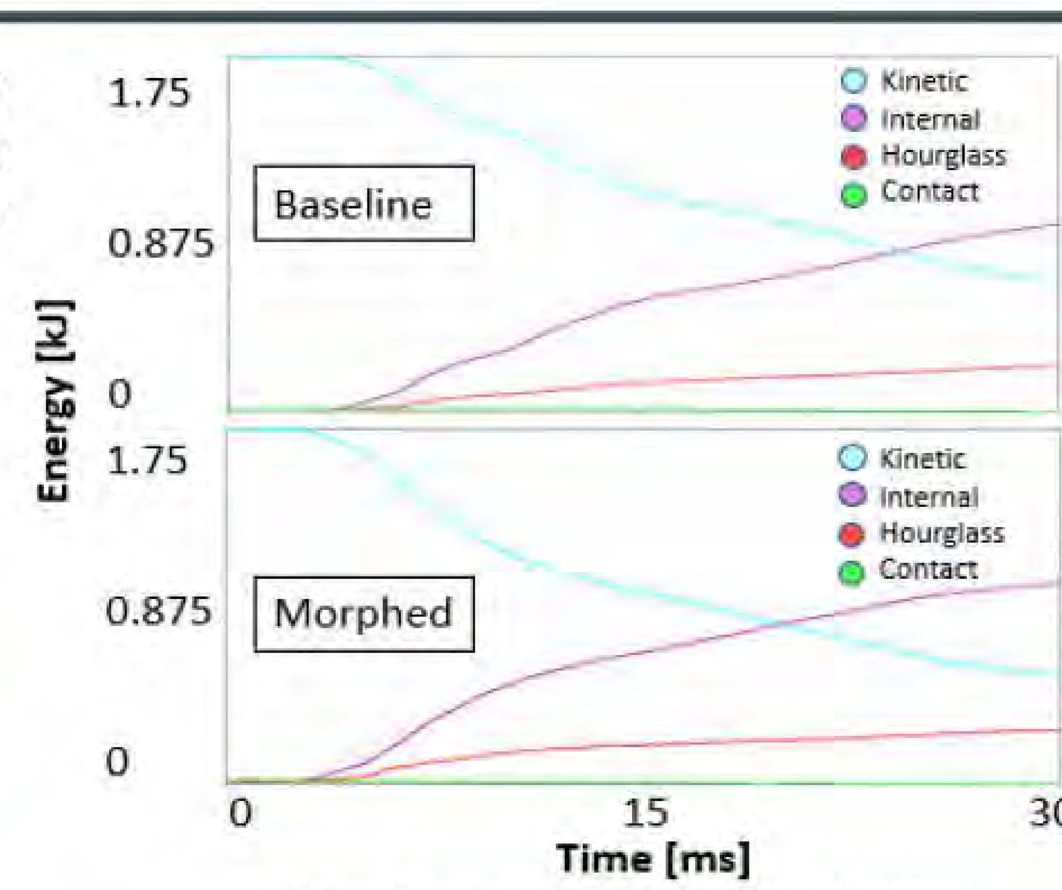

Figure 9: Energy balance for both the cases

Crash Test: Figure 8 shows the deformation of the Baseline and Morphed bonnets. During the impact, the Kinetic Energy (KE) is predominantly transformed into Internal Energy (IE), as shown in **Figure 9**. At 30 ms, IE and KE detected for Baseline are 0.89 kJ and 0.64 kJ while for Morphed are 0.98 kJ and 0.53 kJ.

Conclusion

This work has shown a new direct coupling of the explicit *LS-DYNA* solver integrated into *Ansys Workbench and Ansys Mechanical* with *RBF Morph* software. This method has been applied to open the bonnet of a car, to morph it on another surface and to perform Crash tests. For future developments, the encouraging results show how it is possible to integrate these tools into a shape and design optimization procedure aimed at improving the quality of the final product.

[1] Biancolini, M. E. (2017). Fast radial basis functions for engineering applications. Springer International Publishing.
[2] https://www.nhtsa.gov/crash-simulation-vehicle-models

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